General

Guideline Title

KDIGO clinical practice guideline for acute kidney injury.

Bibliographic Source(s)

KDIGO clinical practice guideline for acute kidney injury. Kidney Int Suppl. 2012 Mar;2(1):1-138. [783 references]

Guideline Status

This is the current release of the guideline.

Recommendations

Major Recommendations

Definitions for grade for overall quality of evidence (A-D, Not Graded) and implications of the strength of recommendations (Level 1 and Level 2) are given at the end of the "Major Recommendations" field.

Acute Kidney Injury (AKI) Definition

Definition and Classification of AKI

Definition and Staging of AKI

2.1.1: AKI is defined as any of the following (*Not Graded*):

- Increase in serum creatinine (SCr) by ≥0.3 mg/dl (≥26.5 µmol/l) within 48 hours; or
- Increase in SCr to ≥1.5 times baseline, which is known or presumed to have occurred within the prior 7 days; or
- Urine volume <0.5 ml/kg/h for 6 hours

2.1.2: AKI is staged for severity according to the following criteria (see the table below). (*Not Graded*)

Table. Staging of Acute Kidney Injury (AKI)

Stage	Serum Creatinine	Urine Output
1	1.5–1.9 times baseline OR ≥0.3 mg/dl (≥26.5 µmol/l) increase	<0.5 ml/kg/h for 6–12 hours

Stage	Serum Creatinine	Urine Output
2	2.0–2.9 times baseline	<0.5 ml/kg/h for ≥12 hours
3	3.0 times baseline OR Increase in serum creatinine to ≥4.0 mg/dl (≥353.6 μmol/l) OR Initiation of renal replacement therapy OR, In patients <18 years, decrease in estimated glomerular filtration rate (eGFR) to <35 ml/min per 1.73 m^2	<0.3 ml/kg/h for ≥24 hours OR Anuria for ≥12 hours

2.1.3: The cause of AKI should be determined whenever possible. (*Not Graded*)

Risk Assessment

2.2.1: The Work Group recommends that patients be stratified for risk of AKI according to their susceptibilities and exposures. (*1B*)

2.2.2: Manage patients according to their susceptibilities and exposures to reduce the risk of AKI (see relevant guideline sections). (*Not Graded*)

2.2.3: Test patients at increased risk for AKI with measurements of SCr and urine output to detect AKI. (*Not Graded*) Individualize frequency and duration of monitoring based on patient risk and clinical course. (*Not Graded*)

Evaluation and General Management of Patients with and at Risk for AKI

2.3.1: Evaluate patients with AKI promptly to determine the cause, with special attention to reversible causes. (*Not Graded*)

2.3.2: Monitor patients with AKI with measurements of SCr and urine output to stage the severity, according to Recommendation 2.1.2. (*Not Graded*)

2.3.3: Manage patients with AKI according to the stage (see Figure 4 in the original guideline document) and cause. (*Not Graded*)

2.3.4: Evaluate patients 3 months after AKI for resolution, new onset, or worsening of pre-existing chronic kidney disease (CKD). (*Not Graded*)

- If patients have CKD, manage these patients as detailed in the Kidney Disease Outcome Quality Initiative (KDOQI) CKD Guideline (Guidelines 7–15). (*Not Graded*)
- If patients do not have CKD, consider them to be at increased risk for CKD and care for them as detailed in the KDOQI CKD Guideline 3 for patients at increased risk for CKD. (*Not Graded*)

Prevention and Treatment of AKI

Hemodynamic Monitoring and Support for Prevention and Management of AKI

Fluids

3.1.1: In the absence of hemorrhagic shock, the Work Group suggests using isotonic crystalloids rather than colloids (albumin or starches) as initial management for expansion of intravascular volume in patients at risk for AKI or with AKI. (*2B*)

Vasopressors

3.1.2: The Work Group recommends the use of vasopressors in conjunction with fluids in patients with vasomotor shock with, or at risk for, AKI. (*1C*)

Protocolized Hemodynamic Management

3.1.3: The Work Group suggests using protocol-based management of hemodynamic and oxygenation parameters to prevent development or worsening of AKI in high-risk patients in the perioperative setting (*2C*) or in patients with septic shock. (*2C*)

Glycemic Control and Nutritional Support

Glycemic Control in Critical Illness: Renal Effects and Outcomes

3.3.1: In critically ill patients, the Work Group suggests insulin therapy targeting plasma glucose 110–149 mg/dl (6.1–8.3 mmol/l). (*2C*)

Nutritional Aspects in the Prevention and Treatment of Critically Ill Patients with AKI

3.3.2: The Work Group suggests achieving a total energy intake of 20–30 kcal/kg/d in patients with any stage of AKI. (*2C*)

3.3.3: The Work Group suggests to avoid restriction of protein intake with the aim of preventing or delaying initiation of renal replacement therapy (RRT). (*2D*)

3.3.4: The Work Group suggests administering 0.8–1.0 g/kg/d of protein in noncatabolic AKI patients without need for dialysis (*2D*), 1.0–1.5 g/kg/d in patients with AKI on RRT (*2D*), and up to a maximum of 1.7 g/kg/d in patients on continuous renal replacement therapy (CRRT) and in hypercatabolic patients. (*2D*)

3.3.5: The Work Group suggests providing nutrition preferentially via the enteral route in patients with AKI. (*2C*)

The Use of Diuretics in AKI

3.4.1: The Work Group recommends not using diuretics to prevent AKI. (*1B*)

3.4.2: The Work Group suggests not using diuretics to treat AKI, except in the management of volume overload. (*2C*)

Vasodilator Therapy: Dopamine, Fenoldopam, and Natriuretic Peptides

Dopamine for the Prevention or Treatment of AKI

3.5.1: The Work Group recommends not using low-dose dopamine to prevent or treat AKI. (*1A*)

Fenoldopam for the Prevention or Treatment of AKI

3.5.2 The Work Group suggests not using fenoldopam to prevent or treat AKI. (*2C*)

Natriuretic Peptides for the Prevention or Treatment of AKI

3.5.3: The Work Group suggests not using atrial natriuretic peptide (ANP) to prevent (*2C*) or treat (*2B*) AKI.

Growth Factor Intervention

3.6.1: The Work Group recommends not using recombinant human insulin-like growth factor-1 (rh)IGF-1 to prevent or treat AKI. (*1B*)

Adenosine Receptor Antagonists

3.7.1: The Work Group suggests that a single dose of theophylline may be given in neonates with severe perinatal asphyxia, who are at high risk of AKI. (*2B*)

Prevention of Aminoglycoside- and Amphotericin-related AKI

Aminoglycoside Nephrotoxicity

3.8.1: The Work Group suggests not using aminoglycosides for the treatment of infections unless no suitable, less nephrotoxic, therapeutic alternatives are available. (*2A*)

3.8.2: The Work Group suggests that, in patients with normal kidney function in steady state, aminoglycosides are administered as a single dose daily rather than multiple-dose daily treatment regimens. (*2B*)

3.8.3: The Work Group recommends monitoring aminoglycoside drug levels when treatment with multiple daily dosing is used for more than 24 hours. (*1A*)

3.8.4: The Work Group suggests monitoring aminoglycoside drug levels when treatment with single-daily dosing is used for more than 48 hours. (*2C*)

3.8.5: The Work Group suggests using topical or local applications of aminoglycosides (e.g., respiratory aerosols, instilled antibiotic beads), rather than intravenous (i.v.) application, when feasible and suitable. (*2B*)

Amphotericin B Nephrotoxicity

3.8.6: The Work Group suggests using lipid formulations of amphotericin B rather than conventional formulations of amphotericin B. (*2A*)

3.8.7: In the treatment of systemic mycoses or parasitic infections, the Work Group recommends using azole antifungal agents and/or the echinocandins rather than conventional amphotericin B, if equal therapeutic efficacy can be assumed. (*1A*)

Other Methods of Prevention of AKI in the Critically Ill

On-Pump Versus Off-Pump Coronary Artery Bypass Surgery

3.9.1: The Work Group suggests that off-pump coronary artery bypass graft surgery not be selected solely for the purpose of reducing perioperative AKI or need for RRT. (*2C*)

3.9.2: The Work Group suggests not using N-acetylcysteine (NAC) to prevent AKI in critically ill patients with hypotension. (*2D*)

NAC in Critically Ill Patients

3.9.3: The Work Group recommends not using oral or i.v. NAC for prevention of postsurgical AKI. (*1A*)

Contrast-induced AKI

Contrast-induced AKI: Definition, Epidemiology, and Prognosis

Background

4.1: Define and stage AKI after administration of intravascular contrast media as per Recommendations 2.1.1–2.1.2. (*Not Graded*)

4.1.1: In individuals who develop changes in kidney function after administration of intravascular contrast media, evaluate for contrast-induced acute kidney injury (CI-AKI) as well as for other possible causes of AKI. (*Not Graded*)

Assessment of the Population at Risk for CI-AKI

4.2.1 Assess the risk for CI-AKI and, in particular, screen for pre-existing impairment of kidney function in all patients who are considered for a procedure that requires intravascular (i.v. or intraarterial [i.a.]) administration of iodinated contrast medium. (*Not Graded*)

4.2.2: Consider alternative imaging methods in patients at increased risk for CI-AKI. (*Not Graded*)

Nonpharmacological Prevention Strategies of CI-AKI

Dose/Volume of Contrast-Media Administration

4.3.1: Use the lowest possible dose of contrast medium in patients at risk for CI-AKI. (*Not Graded*)

Selection of a Contrast Agent

4.3.2: The Work Group recommends using either iso-osmolar or low-osmolar iodinated contrast media, rather than high-osmolar iodinated contrast media in patients at increased risk of CI-AKI. (*1B*)

Pharmacological Prevention Strategies of CI-AKI

Fluid Administration

4.4.1: The Work Group recommends i.v. volume expansion with either isotonic sodium chloride or sodium bicarbonate solutions, rather than no i.v. volume expansion, in patients at increased risk for CI-AKI. (*1A*)

4.4.2: The Work Group recommends not using oral fluids alone in patients at increased risk of CI-AKI. (*1C*)

Role of NAC in the Prevention of CI-AKI

4.4.3: The Work Group suggests using oral NAC, together with i.v. isotonic crystalloids, in patients at increased risk of CI-AKI. (*2D*)

Theophylline and Fenoldopam in Prevention of CI-AKI

Theophylline

4.4.4: The Work Group suggests not using theophylline to prevent CI-AKI. (*2C*)

Fenoldopam

4.4.5: The Work Group recommends not using fenoldopam to prevent CI-AKI. (*1B*)

Effects of Hemodialysis or Hemofiltration

4.5.1: The Work Group suggests not using prophylactic intermittent hemodialysis (IHD) or hemofiltration (HF) for contrast-media removal in patients at increased risk for CI-AKI. (*2C*)

Dialysis Interventions for Treatment of AKI

Timing of Renal Replacement Therapy in AKI

5.1.1: Initiate RRT emergently when life-threatening changes in fluid, electrolyte, and acid-base balance exist. (*Not Graded*)

5.1.2: Consider the broader clinical context, the presence of conditions that can be modified with RRT, and trends of laboratory tests—rather than single blood urea nitrogen (BUN) and creatinine thresholds alone—when making the decision to start RRT. (*Not Graded*)

Criteria for Stopping Renal Replacement Therapy in AKI

5.2.1: Discontinue RRT when it is no longer required, either because intrinsic kidney function has recovered to the point that it is adequate to meet patient needs, or because RRT is no longer consistent with the goals of care. (*Not Graded*)

5.2.2: The Work Group suggests not using diuretics to enhance kidney function recovery, or to reduce the duration or frequency of RRT. (*2B*)

Anticoagulation

5.3.1: In a patient with AKI requiring RRT, base the decision to use anticoagulation for RRT on assessment of the patient's potential risks and benefits from anticoagulation (see Figure 17 in the original guideline document). (*Not Graded*)

5.3.1.1: The Work Group recommends using anticoagulation during RRT in AKI if a patient does not have an increased bleeding risk or impaired coagulation and is not already receiving systemic anticoagulation. (*1B*)

5.3.2: For patients without an increased bleeding risk or impaired coagulation and not already receiving effective systemic anticoagulation, the Work Group suggests the following:

5.3.2.1: For anticoagulation in intermittent RRT, the Work Group recommends using either unfractionated or low-molecular-weight heparin, rather than other anticoagulants. (*1C*)

5.3.2.2: For anticoagulation in continuous renal replacement therapy (CRRT), the Work Group suggests using regional citrate anticoagulation rather than heparin in patients who do not have contraindications for citrate. (*2B*)

5.3.2.3: For anticoagulation during CRRT in patients who have contraindications for citrate, the Work Group suggests using either unfractionated or low-molecular-weight heparin, rather than other anticoagulants. (*2C*)

5.3.3: For patients with increased bleeding risk who are not receiving anticoagulation, the Work Group suggests the following for anticoagulation during RRT:

5.3.3.1: The Work Group suggests using regional citrate anticoagulation, rather than no anticoagulation, during CRRT in a patient without contraindications for citrate. (*2C*)

5.3.3.2: The Work Group suggests avoiding regional heparinization during CRRT in a patient with increased risk of bleeding. (*2C*)

5.3.4: In a patient with heparin-induced thrombocytopenia (HIT), all heparin must be stopped and the Work Group recommends using direct thrombin inhibitors (such as argatroban) or Factor Xa inhibitors (such as danaparoid or fondaparinux) rather than other or no anticoagulation during RRT. (*1A*)

5.3.4.1: In a patient with HIT who does not have severe liver failure, the Work Group suggests using argatroban rather than other thrombin or Factor Xa inhibitors during RRT. (*2C*)

Vascular Access for Renal Replacement Therapy in AKI

5.4.1: The Work Group suggests initiating RRT in patients with AKI via an uncuffed nontunneled dialysis catheter, rather than a tunneled catheter.

(*2D*)

5.4.2: When choosing a vein for insertion of a dialysis catheter in patients with AKI, consider these preferences (*Not Graded*):

- First choice: right jugular vein
- Second choice: femoral vein
- Third choice: left jugular vein
- Last choice: subclavian vein with preference for the dominant side

5.4.3: The Work Group recommends using ultrasound guidance for dialysis catheter insertion. (*1A*)

5.4.4: The Work Group recommends obtaining a chest radiograph promptly after placement and before first use of an internal jugular or subclavian dialysis catheter. (*1B*)

5.4.5: The Work Group suggests not using topical antibiotics over the skin insertion site of a nontunneled dialysis catheter in intensive care unit (ICU) patients with AKI requiring RRT. (*2C*)

5.4.6: The Work Group suggests not using antibiotic locks for prevention of catheter-related infections of nontunneled dialysis catheters in AKI requiring RRT. (*2C*)

Dialyzer Membranes for Renal Replacement Therapy in AKI

5.5.1: The Work Group suggests to use dialyzers with a biocompatible membrane for IHD and CRRT in patients with AKI. (*2C*)

Modality of Renal Replacement Therapy for Patients with AKI

5.6.1: Use continuous and intermittent RRT as complementary therapies in AKI patients. (*Not Graded*)

5.6.2: The Work Group suggests using CRRT, rather than standard intermittent RRT, for hemodynamically unstable patients. (*2B*)

5.6.3: The Work Group suggests using CRRT, rather than intermittent RRT, for AKI patients with acute brain injury or other causes of increased intracranial pressure or generalized brain edema. (*2B*)

Buffer Solutions for Renal Replacement Therapy in Patients with AKI

5.7.1: The Work Group suggests using bicarbonate, rather than lactate, as a buffer in dialysate and replacement fluid for RRT in patients with AKI. (*2C*)

5.7.2: The Work Group recommends using bicarbonate, rather than lactate, as a buffer in dialysate and replacement fluid for RRT in patients with AKI and circulatory shock. (*1B*)

5.7.3: The Work Group suggests using bicarbonate, rather than lactate, as a buffer in dialysate and replacement fluid for RRT in patients with AKI and liver failure and/or lactic acidemia. (*2B*)

5.7.4: The Work Group recommends that dialysis fluids and replacement fluids in patients with AKI, at a minimum, comply with American Association of Medical Instrumentation (AAMI) standards regarding contamination with bacteria and endotoxins. (*1B*)

Dose of RRT in AKI

5.8.1: The dose of RRT to be delivered should be prescribed before starting each session of RRT. (*Not Graded*) The Work Group recommends frequent assessment of the actual delivered dose in order to adjust the prescription. (*1B*)

5.8.2: Provide RRT to achieve the goals of electrolyte, acid-base, solute, and fluid balance that will meet the patient's needs. (*Not Graded*)

5.8.3: The Work Group recommends delivering a Kt/V of 3.9 per week when using intermittent or extended RRT in AKI. (*1A*)

5.8.4: The Work Group recommends delivering an effluent volume of 20–25 ml/kg/h for CRRT in AKI (*1A*). This will usually require a higher prescription of effluent volume. (*Not Graded*)

Definitions:

Quality of Supporting Evidence

Grade	Quality of Evidence	Meaning
A	High	The Work Group is confident that the true effect lies close to that of the estimate of the effect.
B	Moderate	The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
C	Low	The true effect may be substantially different from the estimate of the effect.
D	Very low	The estimate of effect is very uncertain, and often will be far from the truth.

Strength of Recommendation

Grade*	Implications		
	Patients	Clinicians	Policy
Level 1 "The Work Group recommends"	Most people in your situation would want the recommended course of action and only a small proportion would not.	Most patients should receive the recommended course of action.	The recommendation can be evaluated as a candidate for developing a policy or a performance measure.
Level 2 "The Work Group suggests"	The majority of people in your situation would want the recommended course of action, but many would not.	Different choices will be appropriate for different patients. Each patient needs help to arrive at a management decision consistent with her or his values and preferences.	The recommendation is likely to require substantial debate and involvement of stakeholders before policy can be determined.

*The additional category "Not Graded" was used, typically, to provide guidance based on common sense or where the topic does not allow adequate application of evidence. The most common examples include recommendations regarding monitoring intervals, counseling, and referral to other clinical specialists. The ungraded recommendations are generally written as simple declarative statements, but are not meant to be interpreted as being stronger recommendations than Level 1 or 2 recommendations.

Clinical Algorithm(s)

The following algorithms are available in the original guideline document:

- Evaluation of AKI according to the stage and cause
- GFR/SCr algorithm
- Flow-chart summary of recommendations (for anticoagulation)

Scope

Disease/Condition(s)

Acute kidney injury (AKI)

Guideline Category

Diagnosis

Evaluation

Management

Prevention

Risk Assessment

Screening

Treatment

Clinical Specialty

Cardiology

Critical Care

Emergency Medicine

Family Practice

Infectious Diseases

Internal Medicine

Nephrology

Nutrition

Pediatrics

Preventive Medicine

Radiology

Intended Users

Advanced Practice Nurses

Allied Health Personnel

Health Care Providers

Health Plans

Hospitals

Managed Care Organizations

Nurses

Patients

Physician Assistants

Physicians

Public Health Departments

Utilization Management

Guideline Objective(s)

- To provide a clinical practice guideline with recommendations for acute kidney injury (AKI) using an evidence-based approach

- To assist the practitioner caring for patients at risk for or with AKI in evaluation and in selecting treatments (among the different options) to improve patient survival and preserve or recover kidney function

Target Population

Adults and children at risk for or with acute kidney injury (AKI)

Interventions and Practices Considered

Risk Assessment/Evaluation

1. Acute kidney injury (AKI) staging for severity according to standard criteria
2. Determining cause of AKI
3. Stratification of patients

Prevention/Treatment/Management

1. Isotonic crystalloids for expansion of intravascular volume
2. Use of vasopressors
3. Protocol-based hemodynamic and oxygenation parameters
4. Insulin therapy for critically ill
5. Nutritional intake, including appropriate energy and protein, via enteral route in patients with AKI
6. Theophylline for neonates
7. Prevention of aminoglycoside- and amphotericin-related AKI
    - Single daily dose vs multiple daily doses of aminoglycosides
    - Topical or local applications vs intravenous (i.v.) when feasible and suitable
    - Lipid formulations of amphotericin B
    - Use of azole antifungal agents and/or echinocandins
8. Assessment of risk of contrast-induced (CI)-AKI
    - Screen for kidney function impairment
    - Consider alternative imaging methods
9. Nonpharmacological prevention
    - Lowest possible dose of contrast medium
    - Iso-osmolar or low-osmolar iodinated contrast
10. Pharmacological prevention
    - i.v. volume expansion with either isotonic sodium chloride or sodium bicarbonate
    - Oral N-acetylcysteine (NAC) with i.v. isotonic crystalloids
11. Anticoagulation
12. Renal replacement therapy (RRT)
    - Vascular access
    - Dialyzer membranes
    - Continuous renal replacement therapy (CRRT) and intermittent RRT
    - Buffer solutions
    - Prescribed dosage

Note: Use of diuretics, vasodilator therapy, growth factor interventions, coronary artery bypass surgery, N-acetylcysteine (NAC), or prophylactic intermittent hemodialysis (IHD) or hemofiltration (HF) is not recommended.

Major Outcomes Considered

- Sensitivity and specificity of diagnostic tests
- Categorical creatinine- or glomerular filtration rate (GFR)-based outcomes for AKI
- Need for or dependence on renal replacement therapy (RRT)
- Mortality

- Catheter or filter survival
- Infections
- Bleeding
- Metabolic complications
- Adverse effects of treatment
- Safety
- Morbidity
- Cost-effectiveness

Methodology

Methods Used to Collect/Select the Evidence

Hand-searches of Published Literature (Primary Sources)

Hand-searches of Published Literature (Secondary Sources)

Searches of Electronic Databases

Description of Methods Used to Collect/Select the Evidence

Literature Search and Article Selection

The MEDLINE, Cochrane Central Registry for trials, and Cochrane database of systematic reviews were searched by the Evidence Review Team (ERT) to capture all citations relevant to the topic of acute kidney injury (AKI), including original articles and existing systematic reviews. The search was limited to publications since 1980. For constast-induced (CI)-AKI, the ERT limited the search to publications from 1995 onward, since prior to this date the use of high-osmolar contrast agents was common. The introduction of low-osmolar contrast agents after this date resulted in testing interventions in studies using low-osmolar contrast media. Finally, when an iso-osmolar agent became available, the ERT examined studies of this agent against low-osmolar contrast agents.

A list of pertinent existing systematic reviews relevant to the guidelines was generated, organized by topic, and reviewed with the Work Group. If an existing systematic review adequately addressed a question of interest, and was deemed to be of sufficient quality, based on methodological rigor, this was used instead of the ERT conducting a de novo systematic review. This systematic review was then used as the starting point for building the evidence base, and was supplemented with articles from the own searches. The searches were updated through December 16, 2010. All searches were then supplemented by articles identified by Work Group members through February 2011.

During abstract screening, journal articles reporting original data were reviewed. Editorials, letters, stand-alone abstracts, unpublished reports, and articles published in non–peer-reviewed journals were excluded. The Work Group also decided to exclude publications from journal supplements and conference proceedings, because of potential differences in the way these papers are solicited, selected, reviewed, and edited compared to peer-reviewed publications.

MEDLINE and Cochrane search results were screened by the ERT for relevance using predefined eligibility criteria, described below. For questions related to treatment, the systematic search aimed to identify randomized controlled trials (RCTs) with sample sizes as described in Table 19. Restrictions by sample size were based on methodological and clinical considerations. Generally, it was deemed that trials with fewer than 50 patients per arm would be unlikely to be conclusive regarding effect for patient-important clinical outcomes in AKI. However, for specific topics where only sparse data were available (e.g., the use of renal replacement therapy [RRT] to prevent CI-AKI), a lower sample size threshold was used to provide some information for descriptive purposes. For all treatment topics, RCTs in children were included if they met overall inclusion criteria for adults.

See Appendix F of the original guideline document (see the "Availability of Companion Documents" field) for more information on the literature yield for systematic review topics.

Number of Source Documents

Not stated

Methods Used to Assess the Quality and Strength of the Evidence

Weighting According to a Rating Scheme (Scheme Given)

Rating Scheme for the Strength of the Evidence

Quality of Supporting Evidence

Grade	Quality of Evidence	Meaning
A	High	The Work Group is confident that the true effect lies close to that of the estimate of the effect.
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Methods Used to Analyze the Evidence

Review of Published Meta-Analyses

Systematic Review with Evidence Tables

Description of the Methods Used to Analyze the Evidence

Data Extraction

The Evidence Review Team (ERT) designed data-extraction forms to capture information on various aspects of the primary studies. Data fields for all topics included study setting, patient demographics, eligibility criteria, baseline kidney function (creatinine or glomerular filtration rate [GFR]), numbers of subjects randomized, study design, study funding source, descriptions of interventions, description of outcomes, statistical methods used, results, quality of outcomes (as described below), limitations to generalizability, and free-text fields for comments and assessment of biases. Additional data fields contained information relevant to specific questions.

Summary Tables

For each question of intervention, summary tables were developed to tabulate the data from studies pertinent. Each summary table contains a brief description of the baseline characteristics of the population, intervention and control treatments, concomitant therapy, outcomes, and methodological quality for each outcome. Baseline characteristics include a description of the study size, country of residence, age, baseline kidney function, and setting or procedure. The studies were listed by outcome within the table based on the hierarchy of important outcomes (see Table 23 in Appendix F of the original guideline document). Work Group members were asked to proof and review all data and quality assessments in the summary tables on randomized controlled trials (RCTs).

Summary tables and evidence profiles are referenced in the text and published online. They are available at www.kdigo.org .

Grading the Quality of Evidence

A structured approach, based on Grading of Recommendations Assessment, Development and Evaluation (GRADE) and facilitated by the use of evidence profiles, was employed in order to grade the quality of the overall evidence. For each topic, the discussion on grading of the quality of the evidence was led by the ERT. The "quality of a body of evidence" refers to the extent to which confidence in an estimate of effect is sufficient to support a particular recommendation.

See Appendix F of the original guideline document (see the "Availability of Companion Documents" field) for more information on evaluation of individual studies and on grading the quality of evidence.

Methods Used to Formulate the Recommendations

Expert Consensus

Description of Methods Used to Formulate the Recommendations

Overview of Process

Kidney Disease: Improving Global Outcomes (KDIGO) guidelines focus on topics related to the prevention of—or management of individuals with—kidney diseases. General information on the KDIGO guideline development process is available at http://www.kdigo.org/clinical_practice_guidelines/MethodsDevelopment.php .

The development of this particular guideline includes many sequential and concurrent steps:

- Appoint the Work Group and Evidence Review Team (ERT), which were responsible for different aspects of the process.
- Confer to discuss process, methods, and results.
- Develop and refine topics.
- Triage topics to systematic review or narrative review.
- Define specific populations, interventions or predictors, and outcomes of interest for systematic review topics.
- Create and standardize quality assessment methods.
- Create data extraction forms.
- Develop literature search strategies and run searches.
- Screen abstracts and retrieve full articles based on predetermined eligibility criteria.
- Perform "reverse engineering," i.e., use of existing systematic reviews to refine questions.
- Extract data and perform critical appraisal of the literature.
- Grade quality of the outcomes of each study.
- Tabulate data from articles into summary tables.
- Grade the quality of evidence for each outcome and assess the overall quality and findings of bodies of evidence with the aid of evidence profiles.
- Write recommendations and supporting rationale statements.
- Grade the strength of the recommendations based on the quality of the evidence and other considerations.
- Conduct peer review by KDIGO Board of Directors in December, 2009 and the public prior to publication in 2011.

Group Member Selection and Meeting Process

The KDIGO Co-Chairs appointed the Co-Chairs of the Work Group, who then assembled the Work Group to be responsible for the development of the guideline. The Work Group consisted of domain experts, including individuals with expertise in nephrology, critical care medicine, internal medicine, pediatrics, cardiology, radiology, infectious diseases and epidemiology. For support in evidence review, expertise in methods, and guideline development, the National Kidney Foundation (NKF) contracted with the Evidence Review Team (ERT) based primarily at the Tufts Center for Kidney Disease Guideline Development and Implementation at Tufts Medical Center in Boston, Massachusetts, USA. The ERT consisted of physician-methodologists with expertise in nephrology and internal medicine, and research associates and assistants. The ERT instructed and advised Work Group members in all steps of literature review, critical literature appraisal, and guideline development. The Work Group and the ERT collaborated closely throughout the project. The Work Group, KDIGO Co-Chairs, ERT, liaisons, and NKF support staff met for four 2-day meetings for training in the guideline development process, topic discussion, and consensus development.

Evidence Selection, Appraisal, and Presentation

The Work Group and ERT first defined the topics and goals for the guideline and identified key clinical questions for review. The ERT performed literature searches, organized abstract and article screening, coordinated methodological and analytic processes of the report, defined and standardized the search methodology, performed data extraction, and summarized the evidence. The Work Group members reviewed all included articles, data extraction forms, summary tables, and evidence profiles for accuracy and completeness. The four major topic areas of interest for AKI included: i) definition and classification; ii) prevention; iii) pharmacologic treatment; and iv) RRT. Populations of interest were those at risk for

AKI (including those after intravascular contrast-media exposure, aminoglycosides, and amphotericin) and those with or at risk for AKI with a focus on patients with sepsis or trauma, receiving critical care, or undergoing cardiothoracic surgery. The excluded studies were on AKI from rhabdomyolysis, specific infections, and poisoning or drug overdose.

Outcome Selection Judgments, Values, and Preferences

The Work Group and ERT limited outcomes to those important for decision making, including development of AKI, need for or dependence on RRT, and all-cause mortality. When weighting the evidence across different outcomes, the Work Group selected as the "crucial" outcome that which weighed most heavily in the assessment of the overall quality of evidence. Values and preferences articulated by the Work Group included: i) a desire to be inclusive in terms of meeting criteria for AKI; ii) a progressive approach to risk and cost such that, as severity increased, the group put greater value on possible effectiveness of strategies, but maintained high value for avoidance of harm; iii) intent to guide practice but not limit future research.

Grading the Strength of Recommendations

A structured approach, based on Grading of Recommendations Assessment, Development and Evaluation (GRADE) and facilitated by the use of evidence profiles, was employed in order to grade the strength of a recommendation. For each topic, the discussion on grading of the quality of the evidence was led by the ERT, and the discussion regarding the strength of the recommendations was led by the Work Group Chairs. The "strength of a recommendation" indicates the extent to which one can be confident that adherence to the recommendation will do more good than harm.

See Appendix F of the original guideline document (see the "Availability of Companion Documents" field) for more detailed methods.

Rating Scheme for the Strength of the Recommendations

Strength of Recommendation

Grade*	Implications		
	Patients	Clinicians	Policy
Level 1 "The Work Group recommends"	Most people in your situation would want the recommended course of action and only a small proportion would not.	Most patients should receive the recommended course of action.	The recommendation can be evaluated as a candidate for developing a policy or a performance measure.
Level 2 "The Work Group suggests"	The majority of people in your situation would want the recommended course of action, but many would not.	Different choices will be appropriate for different patients. Each patient needs help to arrive at a management decision consistent with her or his values and preferences.	The recommendation is likely to require substantial debate and involvement of stakeholders before policy can be determined.

*The additional category "Not Graded" was used, typically, to provide guidance based on common sense or where the topic does not allow adequate application of evidence. The most common examples include recommendations regarding monitoring intervals, counseling, and referral to other clinical specialists. The ungraded recommendations are generally written as simple declarative statements, but are not meant to be interpreted as being stronger recommendations than Level 1 or 2 recommendations.

Cost Analysis

The guideline developers reviewed published cost analyses.

Method of Guideline Validation

External Peer Review

Internal Peer Review

Description of Method of Guideline Validation

Guidelines underwent internal review by the Kidney Disease: Improving Global Outcomes (KDIGO) Board of Directors and external public review administered by KDIGO yielded 124 responses. Public review comments were compiled and fed back to the Work Group, which considered comments in its revision of the guideline.

Evidence Supporting the Recommendations

Type of Evidence Supporting the Recommendations

The type of supporting evidence is identified and graded for each recommendation (see the "Major Recommendations" field).

Benefits/Harms of Implementing the Guideline Recommendations

Potential Benefits

Appropriate prevention, diagnosis, treatment, and management of acute kidney injury (AKI)

See also the rationale for each guideline statement for a discussion of the summary of the benefits for each intervention in Sections 3-5 of the original guideline document.

Potential Harms

A summary of the harms for each intervention is provided in Sections 3-5, in summary tables and evidence profiles, and discussed in the rationale for each guideline statement in the original guideline document.

Contraindications

Contraindications

The European Medicines Agency (EMEA) stated a contraindication for use of gadodiamide in patients with a glomerular filtration rate (GFR) <30 ml/min per 1.73m^2, and issued a warning for its use in patients who have a GFR between 30 and 60 ml/min per 1.73 m^2.

Qualifying Statements

Qualifying Statements

Use of the Clinical Practice Guideline

This Clinical Practice Guideline document is based upon the best information available as of February 2011. It is designed to provide information and assist decision-making. It is not intended to define a standard of care, and should not be construed as one, nor should it be interpreted as prescribing an exclusive course of management. Variations in practice will inevitably and appropriately occur when clinicians take into account the needs of individual patients, available resources, and limitations unique to an institution or type of practice. Every health-care professional making use of these recommendations is responsible for evaluating the appropriateness of applying them in the setting of any particular clinical situation. The recommendations for research contained within this document are general and do not imply a specific protocol.

Limitations

There are important limitations to the recommendations for definition and staging of acute kidney injury (AKI), including imprecise determination of risk (see Chapter 2.2 in the original guideline document) and incomplete epidemiology of AKI, especially outside the intensive care unit (ICU). Clinical judgment is required in order to determine if patients seeming to meet criteria do, in fact, have disease, as well as to determine if patients are likely to have AKI even if incomplete clinical data are available to apply the diagnostic criteria. The application of the diagnostic and staging criteria is discussed in greater detail, along with specific examples in Chapter 2.4 of the original guideline document.

The use of urine output criteria for diagnosis and staging has been less well validated and in individual patients the need for clinical judgment regarding the effects of drugs (e.g., angiotensin-converting enzyme inhibitors [ACE-I]), fluid balance, and other factors must be included. For very obese patients, urine output criteria for AKI may include some patients with normal urine output. However, these recommendations serve as the starting point for further evaluation, possibly involving subspecialists, for a group of patients recognized to be at increased risk.

Finally, it is axiomatic that patients always be managed according to the cause of their disease, and thus it is important to determine the cause of AKI whenever possible. In particular, patients with decreased kidney perfusion, acute glomerulonephritis, vasculitis, interstitial nephritis, thrombotic microangiopathy, and urinary tract obstruction require immediate diagnosis and specific therapeutic intervention, in addition to the general recommendations for AKI in the remainder of this guideline (see Table 5 in the original guideline document).

It is recognized that it is frequently not possible to determine the cause, and often the exact cause does not dictate a specific therapy. However, the syndrome of AKI includes some patients with specific kidney diseases (e.g., glomerulonephritis) for which a specific treatment is available. As such, it is always necessary to search for the underlying cause of AKI (see Chapter 2.3 in the original guideline document).

Implementation of the Guideline

Description of Implementation Strategy

An implementation strategy was not provided.

Implementation Tools

Clinical Algorithm

For information about availability, see the *Availability of Companion Documents* and *Patient Resources* fields below.

Institute of Medicine (IOM) National Healthcare Quality Report Categories

IOM Care Need

Getting Better

Staying Healthy

IOM Domain

Effectiveness

Patient-centeredness

Safety

Identifying Information and Availability

Bibliographic Source(s)

KDIGO clinical practice guideline for acute kidney injury. Kidney Int Suppl. 2012 Mar;2(1):1-138. [783 references]

Adaptation

Not applicable: The guideline was not adapted from another source.

Date Released

2012 Mar

Guideline Developer(s)

Kidney Disease: Improving Global Outcomes - Nonprofit Organization

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Guideline Committee

Kidney Disease: Improving Global Outcomes (KDIGO) Work Group

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Financial Disclosures/Conflicts of Interest

Kidney Disease: Improving Global Outcomes (KDIGO) makes every effort to avoid any actual or reasonably perceived conflicts of interest that

may arise as a result of an outside relationship or a personal, professional, or business interest of a member of the Work Group. All members of the Work Group are required to complete, sign, and submit a disclosure and attestation form showing all such relationships that might be perceived or actual conflicts of interest. This document is updated annually and information is adjusted accordingly. All reported information is listed below, is published in its entirety at the end of the original guideline document in the Work Group members' Biographical and Disclosure Information section, and is kept on file at the National Kidney Foundation (NKF), managing Agent for KDIGO.

Individual affiliations and disclosure information are available in the Biographic and Disclosure Information chapter of the original guideline document.

Guideline Status

This is the current release of the guideline.

Guideline Availability

Electronic copies: Available in Portable Document Format (PDF) from the Kidney Disease: Improving Global Outcomes (KDIGO) Web site .

Availability of Companion Documents

The following are available:

- KDIGO clinical practice guideline for acute kidney injury. Online appendices A-F. New York: Kidney Disease: Improving Global Outcomes; 2012 Mar. 132 p. Electronic copies: Available in Portable Document Format (PDF) from the Kidney Disease: Improving Global Outcomes (KDIGO) Web site .
- KDIGO clinical practice guideline for acute kidney injury. Supplementary tables. New York: Kidney Disease: Improving Global Outcomes; 2012 Mar. 64 p. Electronic copies: Available in PDF from the KDIGO Web site .
- Methods for development of KDIGO clinical practice guidelines. Electronic copies: Available from the KDIGO Web site .

Patient Resources

None available

NGC Status

This NGC summary was completed by ECRI Institute on September 24, 2012. This summary was updated by ECRI Institute on March 10, 2014 following the U.S. Food and Drug Administration advisory on Low Molecular Weight Heparins.

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